Indian J. Phys. **70B** (1), 81–85 (1996)

I J P
an international journal

Studies on solar prominences in relation to *H*-alpha and X-ray flares

T N Chatterjee, T K Das and A K Sen

Eastern Centre for Research in Astrophysics, Institute of Radio Physics and Electronics, 92 Acharya Prafulla Chandra Road, Calcutta-700 009, India

Received 31 January 1995, accepted 24 November 1995

Abstract : A study has been made on solar prominences in relation to the *H*-alpha flares accompanied with high speed dark filaments (*H*-type of flares) as well as with X-rays. Most of the *H*-type flares have area 0–80 millionths of solar hemisphere, rise time 0–5 min, duration 0–25 min. The time of onset of this kind of flares always precedes that of filaments in most of cases. The *H*-type flares have a general tendency to be correlated with X ray flares. But when the probability of their occurrences with respect to all the types of flares was calculated for the frequency distributions of area as well as duration, such probability has been found to increase with the increase of the respective quantities. Only in case of rise time such probability remains constant all through.

Keywords : Sun, prominences, flares

PACS No. : 96.60 Rd

Outside the Sun's limb, prominences appear in *H*-alpha brightness on a dark ground, when seen in projection on the disk they look dark, forming structures called filament. Recent observations on solar prominences in the multi-wavelength band, especially in *H*-alpha and X-ray regions [1–3] reveal that an erupting filament plays a major role in the X-ray flare which is associated with the foot print of a prominence. They conjectured about the presence of a preheated plasma in loops adjoint to the prominence structure which is presumed to contribute part of the blue shifted X-ray emission. In our earlier papers [4,5], we made studies on *H*-alpha flares classified according to their visual indications and reported that *H*-alpha flares associated with high speed dark filaments (*H*-type of flares according to the IAU system of notes) are more impulsive and burst productive in the entire radio-wavelength band compared to the other types of flares. We have in this present paper, attempted to search out more features about the *H*-type of flares in relation to the various characteristics of the associated filaments and X-rays.

About 191 data of *H*-alpha flares associated with high speed dark filaments out of 3842 *H*-alpha flares that occurred during the year 1988, were collected from the Solar Geophysical Data Bulletins published by U S Department of Commerce. These flares were correlated with the filaments when their starting times did not differ from each other by + 5 or – 5 min. Similar procedure was adopted for associating this kind of flares with X-ray flares as well.

The results of the analysis are presented under the following headings :

Area of flares accompanied with high speed dark filaments :

The frequency distribution of the area of the *H*-alpha flares with high speed dark filaments as displayed in Figure 1(a) shows that the occurrences of such flares concentrate towards

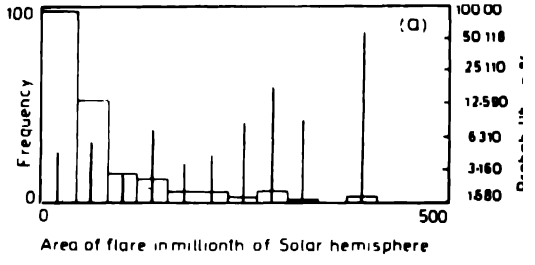

Figure 1(a). Histograms show the occurrence frequency distribution of the areas of flares accompanied with high speed dark filaments (*H*-type of flares in comparison to other types of flares that are found to occur in the adopted ranges of area).

the lower values of area. But when the probability of occurrences of such type of flares with respect to all the *H*-alpha flares in various selected ranges of area are concerned, such

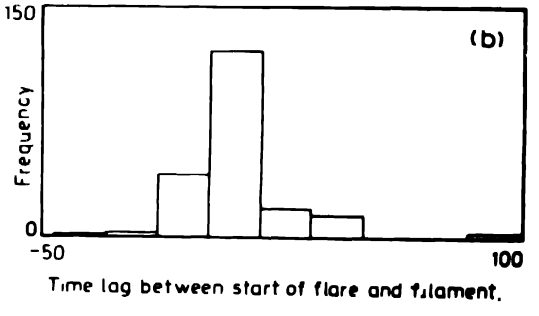

Figure 1(b). Histograms showing the time lag between the starting phase of *H*-type flares and that of associated filaments The sign has been taken as +ve when the time of onset of a flare precedes that of a filament and –ve for the reverse case.

probability distribution more or less increases with the increase of area. Here the probability (σ) has been defined as

$$\sigma = \frac{\text{No. of occurrences of } H\text{ - type of flares having a particular range of area}}{\text{No. of occurrences of all types of flares in the same range of area}}.$$

This result clearly indicates that when *H*-alpha flares are associated with high speed dark filaments, they should have larger extent of area.

Time lag between flare and filament onsets :

The time interval between the starting phase of a flare and that of a filament is found out for each of the correlated events. This interval was taken to be positive when the flare time precedes the filament's time of onset, and negative for the reverse case. The results obtained from the study is displayed in Figure 1(b), from which it can be concluded that in most of the cases, the flare starts ahead of a filament eruption.

Rise-time of flares :

The frequency distribution of the rise times of flares is shown in Figure 1(c) which reveals that most of the flares have rise-times within the range of values 0–5 min. The % probability distribution of occurrences of such type of flares with respect to all the *H*-alpha flares remains almost constant in all the ranges of rise times of flares.

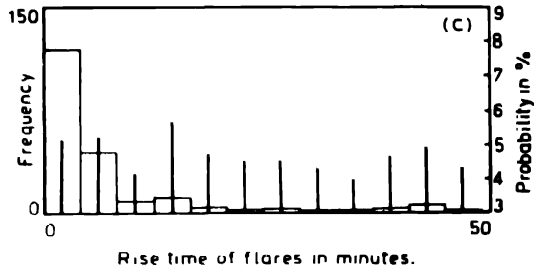

Figure 1(c). Histograms showing the occurrences of *H*-type of flares in different ranges of rise time. The bar lines indicate the probability of occurrence of *H*-type of flares in the adopted ranges of rise time

Duration of filaments and associated H-alpha flares :

The occurrence frequency distribution of duration of filaments is displayed in Figure 2(a) which shows that the occurrence frequency decreases almost exponentially with the

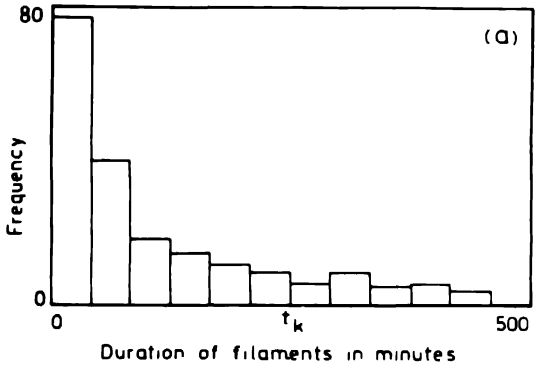

Figure 2(a). Histograms giving the occurrences of filaments in different ranges of duration of filament.

increase of duration. Similar studies were carried out for the filament associated *H*-alpha flares as well. The histograms as shown in Figure 2(b) depict that the number of flares

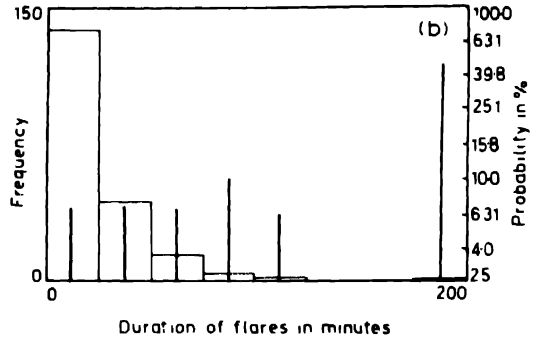

Figure 2(b). Histograms giving the occurrences of flares in various ranges of duration of *H*-type of flares. The bar line designates the occurrence probability of *H*-type of flares in various ranges of duration

crowd towards the smaller values of duration not exceeding 50 min. The bar plot of the probability distribution indicates that the probability of occurrences has an upward trend towards the larger duration values. Here the probability (σ) is defined as follows :

$$\sigma = \frac{\text{No. of occurrences of } H\text{ - type of flares in a particular range of duration}}{\text{No. of occurrences of all types of flares in the same range of duration}}$$

From this study it is clear that the flares which are associated with high speed dark filaments generally possess higher values of duration.

The correlation coefficients in between all these five parameters, taking two at a time, have been computed separately. The correlation coefficients have been found to be insignificant, the values in no case exceed 30%.

Association of flares with X-rays :

The association of flares with X-rays was examined in the last phase of work and the results are displayed in the following Table (Table 1).

Table 1. Flare X-ray association.

Number of *H*-alpha flares	Number of associated X-ray flares	*H*-alpha X-ray association	Number of *H*-type flares	Number of associated X-ray flares	*H*-type flares X-ray association
3842	1314	34.2%	191	119	62.3%

It is observed from the above Table that *H*-alpha flares accompanied with high speed dark filaments are mostly associated with X-ray flares.

The present analysis throws some new light about the *H*-alpha flares accompanied with high speed dark filaments. In this paper, it has been examined that this type of flares

possesses larger values of area as well as duration. The larger area indicates a greater extent of magnetoactive plasma region which is also durable one. Moreover, the probability of association of this kind of flares with X-ray flares is also very high. This results conforms very well to the recent observations [1,2].

Acknowledgments

One of the authors, T N Chatterjee acknowledges the Council of Scientific and Industrial Research (Government of India) for their support to the current work.

References

[1] D A Batchelor and K P Hindsley *Solar Phys* **135** 99 (1991)

[2] G Pearce *Astron. Astrophys* **234** 9 (1990)

[3] G P Apushkinskii *Sov Astron* **32** 688 (1988)

[4] T Chakravorti, T K Das and M K Dasgupta *Bull. Astron. Inst Czechosl* **36** 122 (1985)

[5] M K Dasgupta, T K Das and S K Sarkar *Solar Phys* **64** 323 (1979)